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ENVIRONMENTAL STUDY OF ERTS-1 IMAGERY: LAKE CHAMPLAIN AND VERMONT

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ABSTRACT

Environmental concerns of the State of Vermont currently being stressed include water quality in Lake Champlain and a state-wide land use and capability plan. Significant results obtained from ERTS-1 relate directly to the above concerns. Industrial water pollution and turbidity in Lake Champlain have been identified and mapped and the ERTS pollution data will be used in the developing court suit which Vermont has initiated against the polluters. ERTS imagery has also provided a foundation for updating and revising land use inventories which will be necessary for meeting some of the informational needs of the Land Use and Land Capability Act (Act 250) now in the process of legislative action at the state level. Major classes of land use have been identified and mapped, and substantial progress has been made toward the mapping of such land use divisions as crop and forest type, and wetlands.

I. INTRODUCTION

Among the environmental issues currently in the public spotlight in Vermont, two stand out as particularly important because they involve precedent setting resource management actions at the state level. These issues concern a) water quality in Lake Champlain, and b) land use management. This paper will attempt to address these environmental concerns in terms of some of the significant results obtained from ERTS-1 data analysis at the University of Vermont. The specific significant results forming the focus of this paper include: a) detection and monitoring of industrial water pollution, b) lake turbidity patterns, and c) land use. The general study area for which significant results

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have been obtained relating to the major environmental concerns above is covered by a single ERTS scene which centers approximately on Lake Champlain (Figure 1).

Figure 1. This RBV 2 rendition of the general study area (July 29) shows the Lake Champlain Lowland as the cloud free area around the lake. The turbid, southern arm of Lake Champlain can also be discerned.

Both RBV and MSS data were available and the range of seasonal coverage extends from late summer to midwinter. In spite of above normal cloudiness for the final quarter of 1972, about one-third of all ERTS scenes for this period were largely cloud free.

II. WATER POLLUTION

Major sources of industrial pollution are found on the New York side of Lake Champlain with major important centers of activity at Fort Ticonderoga and along the Saranac River near Plattsburgh. The bulk of the industrial pollutants being discharged into the lake stem mainly from paper manufacturing operations.

A major pollution plume from the new International Paper Company mill just north of Fort Ticonderoga was detected in the October 10th MSS scene. The plume is best seen on bands four and five (.5-.6 and .6-.7 micrometers), image number 15115. The plume appears as a darker tone in the context of the light-toned turbid water of this portion of the lake. Figure 2 shows the plume as rendered by the better contrast provided in MSS band four.

The pattern of the plume is controlled to some degree by a lake bottom diffuser pipe which extends from the treatment plant in a northeasterly direction nearly to the Vermont border. This pipe distributes the water from aeration lagoons which receive the waste products of paper digestion. The lagoons began discharging in March of 1971 at a rate of approximately 21 million gallons per day. Most of the settleable solides are removed in the treatment process, but the waste water is turbid with suspended solids. The waste water is high in sodium, conductivity and oxygen demand, and very high in phosphates. The observed color of the water is a humic, dark reddish-brown.

The State of Vermont has taken legal action against the paper company and the State of New York alleging that the new plant is reducing the water quality of the lake below Vermont standards, and that this polluted water does cross over the state boundry into Vermont. Field observations, in which the plume can be generally defined by physical and chemical parameters indicate the discharge water does cross over into Vermont (see Figure 3). The ERTS-1 imagery depicts this with exactitude, and supports the ground observations. The high phosphate concentrations in the discharge plume provide sufficient nutrients to stimulate algal blooms which contribute to the eutrophication of this part of the lake.

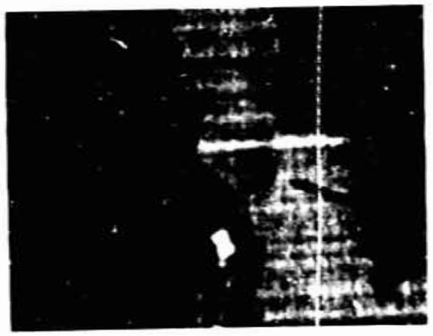

Figure 2. MSS 4 rendition of papermill pollution plume. The bright spot on the left shore is the mill site. Vermont is on the right and the boundary is approximately centered in the lake area.

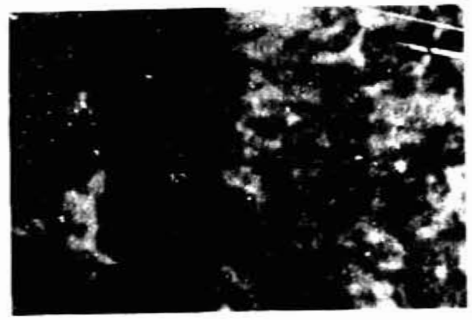

Figure 4. RBV 2 (29 July) showing turbidity boundary.

Figure 5. MSS 4 (10 October) showing extended turbidity pattern.

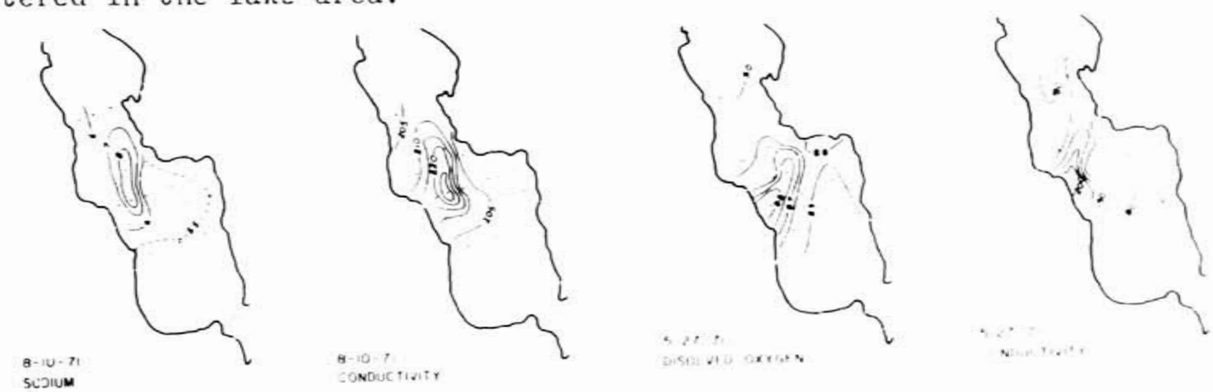

Figure 3. Pattern of chemical/physical water properties showing the plume effect similar to that in Figure 2 above.

III. TURBIDITY

It is well documented that the water in the southern end of the lake is much more turbid than the main lake, and this fact is readily seen on ERTS imagery showing the lake (see Figure 1). Transparency as measured with the Secchi disc is four to six meters in the main lake, but is less than one meter in the southern end. These contrasts are quite apparent where the two water masses meet in the vicinity of Chimney Point, Vermont, and Port Henry, New York (see Figure 4 and 5). A turbidity boundary may be identified from ERTS imagery and fluctuations in this boundary have been observed from two separate satellite coverages.

A particularly prominent extension of turbid water entering the main body of the lake was observed in the October 10 MSS scene (Bands four and five). The ERTS image shows that this turbid plume moves westerly to the western shore of the lake where it then follows the shore towards the north. The turbid water then curls back toward the east until it can no longer be detected. This indicates that the turbid, south-end water becomes part of a large clockwise circulation pattern which dominates the southern end of the main lake body. The above pattern was associated with southeasterly winds which shifted from the southwest about one-half hour before the images were generated. The turbidity patterns in this region of the lake will bear watching and although further study will be required to establish a turbidity pattern model, it is significant that at this time turbidity patterns can be observed and mapped using ERTS data.

IV. LAND USE

A second major environmental concern in Vermont focuses on land use and the development and implementation of state-wide land use regulations. A land use inventory of Vermont was conducted based on conventional aerial photography dating from the early to late 1960's, and it is this information which is being used to support the Land Use and Land Capability Plan currently under legislative review in Vermont. This legislation, known as Act 250, proposes to establish definite land use guidelines and regulations and is in itself considered

a model piece of legislation concerning land use control at the state level. Increasing pressure for land development and conversion of rural to urban land uses are changing land use patterns at a rapid rate, and therefore, it becomes necessary to update the land use inventory.

Major land use categories have been identified and mapped in several substudy areas selected as representative of Vermont land use patterns. Two strictly rural areas, one urban area, and a mountainous, forested area served as a basis for land use studies using ERTS data. All but the last area have been completely mapped at the highest classification level and progress is being made toward mapping at lower classification levels.[1] Because of the patchwork nature of land use patterns and the small unit sizes of such features as cropland, considerable scene enlargement coupled with additive color enhancements were found to be necessary ingredients of the analysis procedure.

Urban and built-up land is one of the major categories that can be mapped from ERTS imagery down to a scale of one inch equals one mile. The Burlington test area provides the best testing ground for such mapping since it constitutes the largest urban area in the state. The map of urban and built-up land (Figure 6) was made from an enlarged, color composite scene from RBV data (Bands one to three, July 29) as generated by a multispectral viewer. In addtion to the simple separation of urban or built-up vs. rural land use, it was also possible to map land use "intensities" at a lower classification level. A first-look analysis of the first Vermont winter scene (8 January) indicates that the best subject/background contrast occurs in winter with thin snow cover, and it appears that this imagery will allow for finer definition of small built-up areas including further subdivision of major built-up areas.

The rural scene in Vermont includes a mosaic of cropland, pasture land, orchards, forests, wetlands, and many streams and lakes. In the agricultural areas, separation of forest tracts from general agricultural land on ERTS imagery may be accomplished from summer or autumn imagery, however slightly better contrast is provided in autumn ERTS coverage, and a first-look at the

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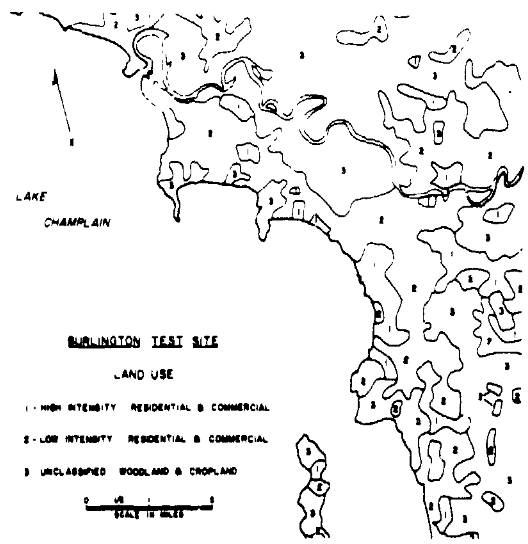
[1]The classification employed here is based on: Anderson, James; Hardy, Ernest E.; and Roach, John 1972. A Land Use Classification for Use With Remote Sensor Data, U. S. Geological Survey Circular 671, 16 pp.

Figure 6. Land use, Burlington test site.



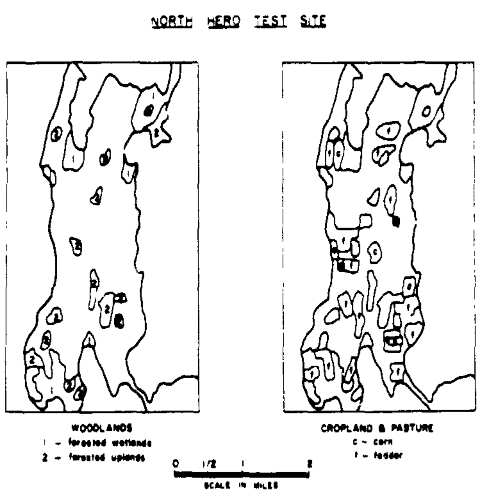


Figure 7. Land use, North Hero test site.

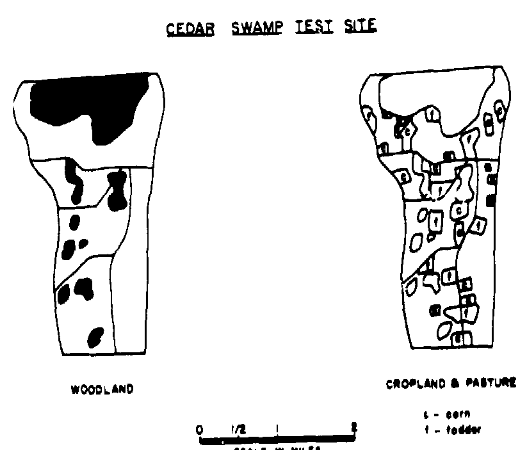


Figure 8. Land use Cedar Swamp test site. Addition of corn and fodder cropland was possible through use of autumn season coverage.

winter scenes just made available allows for very clear definition of all woodland tracts. Wooded wetlands may be differentiated on autumn coverage, and woodland/scrub units seem to be additional units for recognition and mapping from winter scenes.

Presently, it has not been possible to recognize orchards since in the available imagery they are rendered in the same tone/pattern as pastures. However, it is likely that additional seasonal coverage may bear this category out in much the same manner as for example corn fields have been identified by a unique tone produced in autumn imagery. Land use maps generated for the two rural test areas (Figures 7 and 8) are somewhat incomplete in that the cropland/pasture land distinction has not yet been fully made. It is expected that seasonal coverage will reduce the omission error as the autumn coverage did with respect to the summer coverage in the example of corn above. The autumn coverage also allowed for the identification of fields used for fodder crops.

A comparison of a test site map generated from ERTS data with a pre-existing map of land use showed that changes had occurred where woodland areas had increased at the expense of cropland or pasture land. The detail in the enlarged ERTS images was sufficient to allow for corrections in the land use information at state land use mapping scales. The ground checks confirmed these observed changes.

V. SUMMARY

ERTS-1 has provided both timely and significant environmental information for the two major state concerns regarding water quality in Lake Champlain and land use. A major paper mill discharge plume has been identified and this has become part of a precedent setting court suit involving the States of Vermont and New York. A major lake turbidity boundary has been identified and monitored, and the land use data capabilities of ERTS are substantial to the extent that pre-existing maps can be corrected.